Economic Geology
Vol. 98, 2003, pp. 1535–1574

Geology of the Bajo de la Alumbrera Porphyry Copper-Gold Deposit, Argentina

JOHN M. PROFFETT†

P. O. Box 772066, Eagle River, Alaska 99577

Abstract

The Bajo de la Alumbrera porphyry Cu-Au deposit, Argentina, is in the eastern Andes, near the north edge of a region of reverse fault-bound basement uplifts that overlie a low-angle segment of the subduction zone. Alumbrera, now above the transition from steep to flat subduction, formed at ~7 Ma in the Farallón Negro volcanic field, which was active as volcanism was waning regionally above the flattening subduction zone. Reconstruction of volcanic structure suggests that the top of the exposed orebody was emplaced beneath about 2.5 km of andesite and dacite but not directly beneath the vent of a stratovolcano. Production plus remaining resources are 605 million metric (Mt) tons of ore that averages 0.54 percent Cu and 0.64 g/t Au.

The deposit is centered on a closely spaced cluster of small felsic porphyry stocks and dikes, emplaced into andesites during seven phases of intrusion. Dikes of several phases define a radial pattern. Most of the porphyries are very similar to one another, with phenocrysts of plagioclase, hornblende, biotite, and quartz, in a matrix of fine-grained quartz, K-feldspar, and minor plagioclase, biotite, and magnetite. Individual porphyries are distinguished mainly on the basis of intrusive contact relationships.

Highest Cu-Au grades are associated with abundant quartz veins, secondary K-feldspar, ±magnetite, ±biotite, ±anhydrite, in the earliest porphyry (P2), and adjacent andesite. P2-related mineralization is truncated by porphyries of the second phase of ore-related intrusions (Early P3 and Quartz-eye porphyry), which contain similar but generally less intense mineralization and alteration. Porphyries of the next phase (Late P3) truncate mineralization associated with earlier phases and are weakly mineralized with Cu-Au, sparse quartz veins, and secondary biotite. The still later Northwest porphyries truncate most Cu-Au, quartz veins, and potassic alteration, and themselves contain only traces of such mineralization and partially biotitized hornblende. Postmineral porphyries, the youngest, truncate all such mineralization and alteration, and none of their hornblende is biotitized. Los Amarillos porphyry and igneous breccia, along the western periphery of the porphyry cluster, is between P2 and Early P3 in age but shows little relationship to mineralization.

Zones of secondary K-feldspar associated with the earlier porphyries are surrounded by a larger zone of secondary biotite. All significant Cu-Au lies within these potassic zones. The biotite zone is surrounded by epidote-chlorite alteration lacking significant sulfides. Like potassic alteration, epidote-chlorite alteration is also truncated by Postmineral porphyries. Strong feldspar destructive alteration, consisting mostly of veinlet-controlled sericite-quartz-pyrite, is younger than all secondary K-feldspar, biotite, and epidote-chlorite and occurs in a shell in the outer parts of the biotite zone. Weaker feldspar destructive alteration occurs inside and outside this shell. Pyrite veins with sericite-quartz-pyrite alteration cut Postmineral porphyries.

In the earliest secondary K-feldspar assemblage, which is usually barren of Cu sulfides, biotite is altered to magnetite plus K-feldspar. Most Cu sulfides are associated with slightly later K-feldspar-biotite ± magnetite assemblages. Where feldspars and biotite are not overprinted by later feldspar destructive or chloritic alteration, Cu minerals are bornite and chalcopyrite, coexisting with magnetite. Barren as well as Cu sulfide-bearing assemblages are associated with early veinlets, including A-type quartz, which are truncated by the next later porphyry. Deposition of Cu-Au during or between emplacement of closely related porphyries suggests high temperatures and magmatic fluids, and the assemblage bornite-chalcopyrite-magnetite indicates a relatively low sulfidation state, and along with the assemblage K-feldspar-biotite ± magnetite ± anhydrite a relatively high oxidation state. Cu-Au distribution is not related to feldspar destructive zones nor to the interface between sericitic and potassic zones. Much Cu-Au mineralization, however, has been overprinted by late alteration, resulting in partial destruction of feldspars, chloritization of mafics, and sulfidation of bornite-chalcopyrite-magnetite to chalcopyrite-pyrite ± relict magnetite. This probably took place at significantly lower temperature.

A low-grade core zone consists in large part of barren K-feldspar-magnetite alteration and quartz veins in Early P3 porphyry, and in part consists of later barren porphyry, so is mostly younger than the Cu-Au deposited with P2 porphyry.

The youngest features at Alumbrera include small postore normal faults, gypsum veins due to hydration and mobilization of anhydrite, local dissolution of gypsum veins, and locally developed thin zones of near-surface oxidation, leaching, and secondary enrichment.

†E-mail: proffettak@aol.com

0361-0128/01/3393/1535-40 $6.00